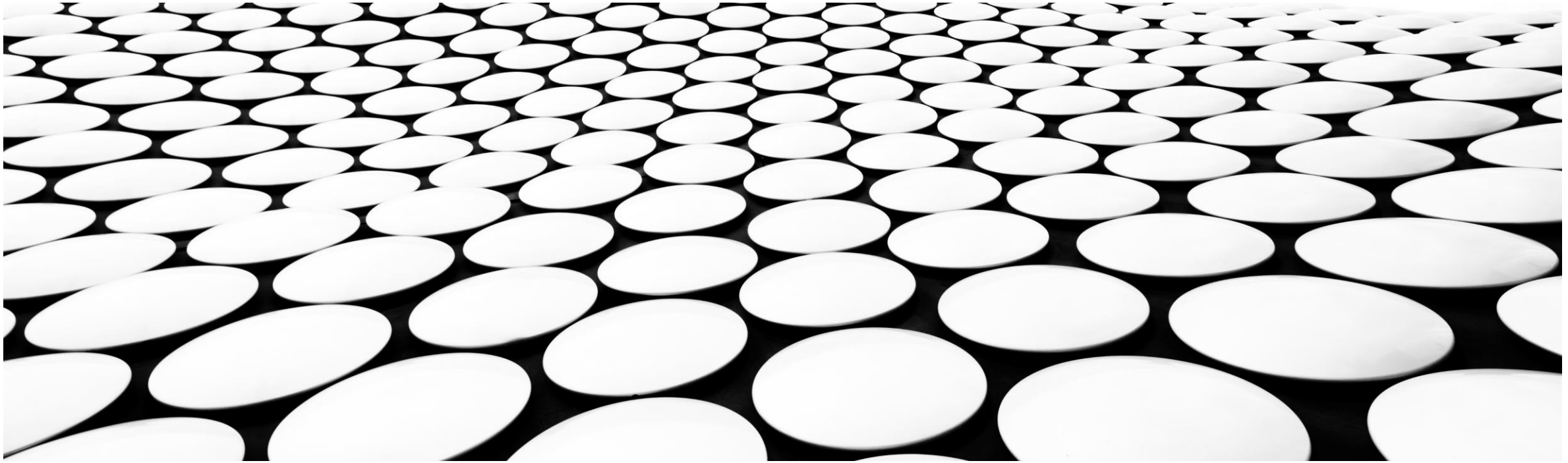
SENSORS & ACTUATORS (MC-511)

DR. ABDUL REHMAN ABBASI



LEARNING OBJECTIVE

Understanding basic laws and phenomena on which operation of sensors and actuators is based

COURSE LEARNING OBJECTIVES

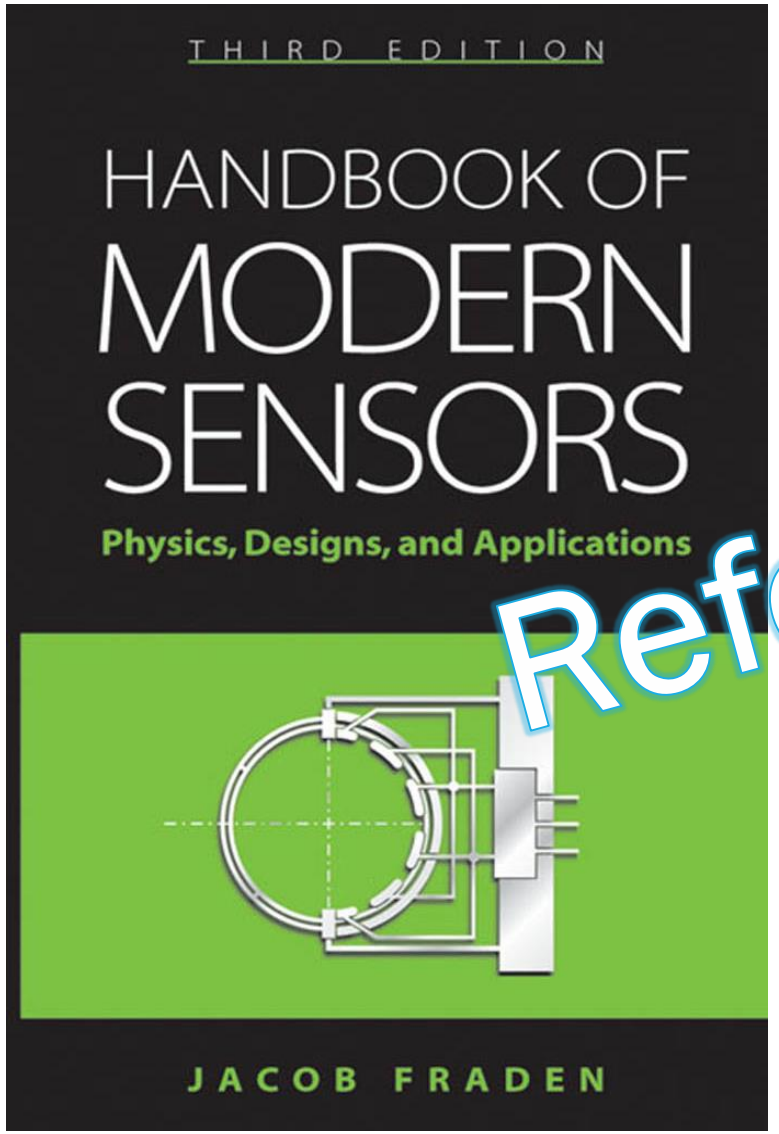
1. The first objective of this course is to understand basics of sensors, actuators and their operating principle.
2. The second objective is to explain working of various types of sensors and actuators.
3. Third objective is to provide information about interfacing of sensors and signal conditioning circuits to establish any control system or monitoring system.
4. The final objective is to provide an understanding on characteristic parameters to evaluate sensor performance

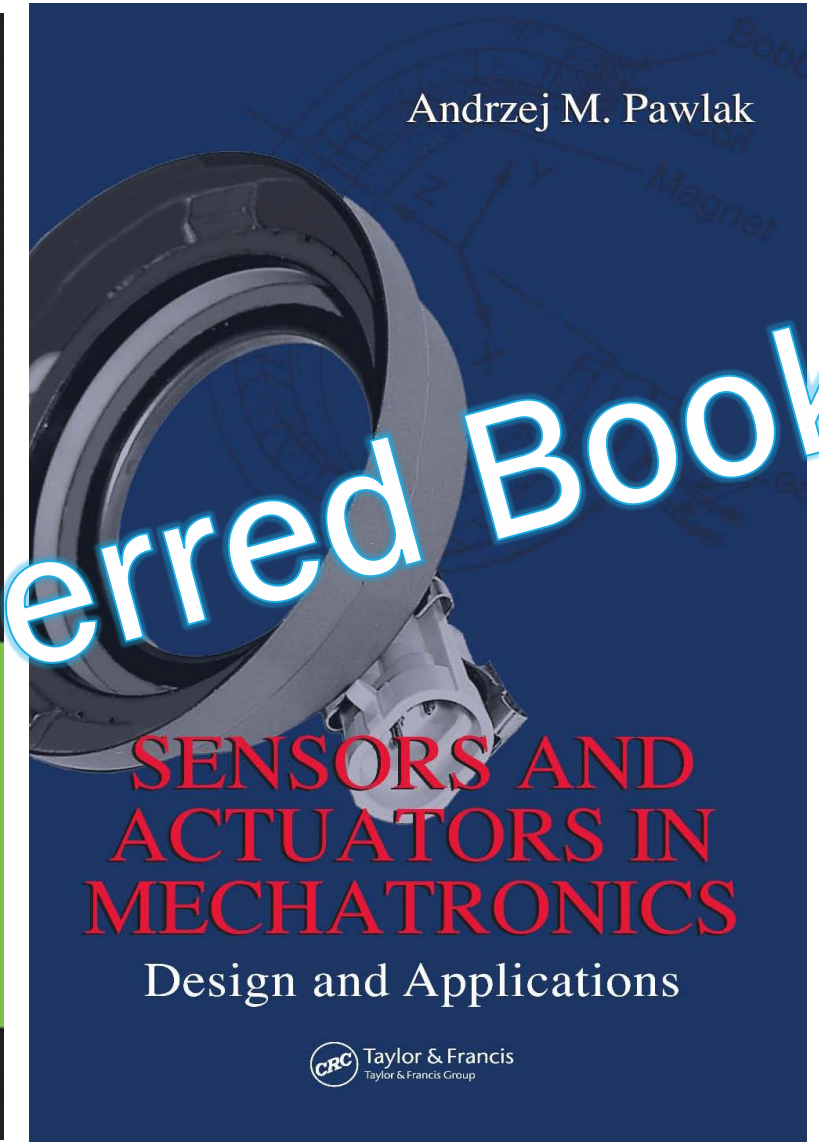
LEARNING OUTCOMES

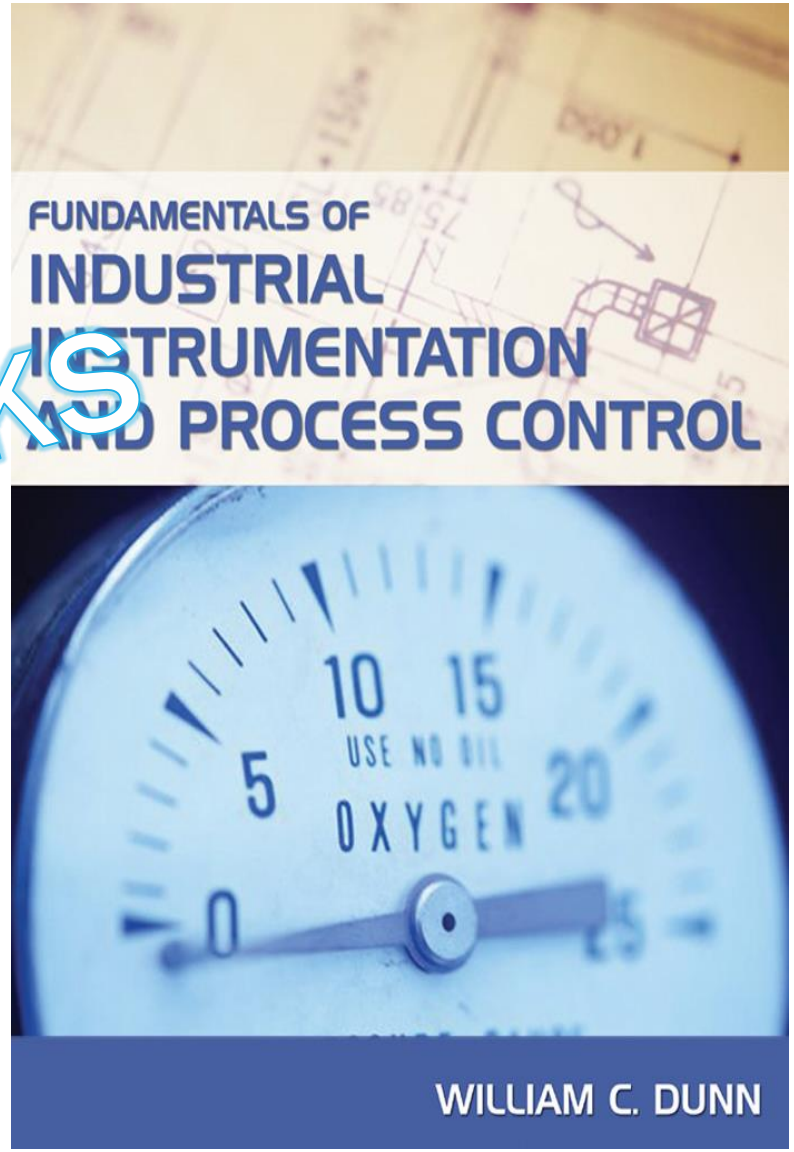
- Explain fundamental physical and technical concepts of sensors and actuators
- Describe basic laws and phenomena that define behavior of sensors and actuators
- Analyze various approaches, procedures and results related to sensors and actuators
- Create analytical design and development solutions for sensors and actuators*

COURSE OUTLINE

- Introduction/Fundamentals of Sensing & Actuation
- Sensing of Common Process Parameters (biomedical, industrial, robotics etc.)
- Actuating devices (industrial controllers, manipulators, motors)
- Signal conditioning
- Signal transmission

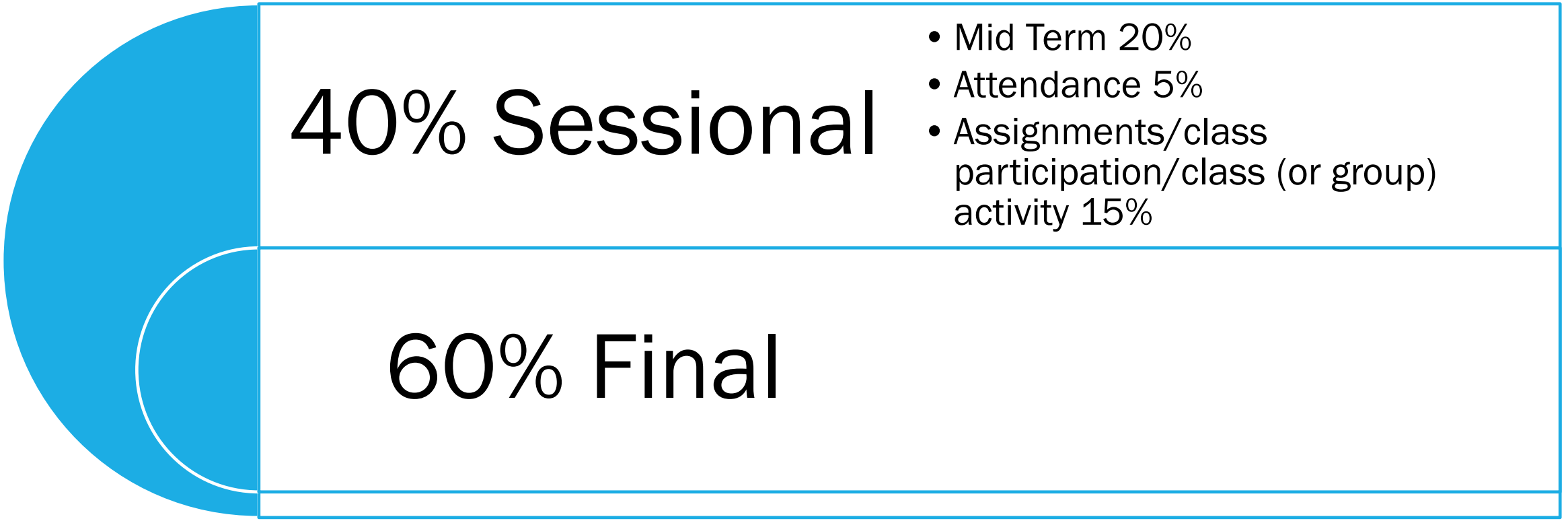






Referred Books

COURSE ASSESSMENT



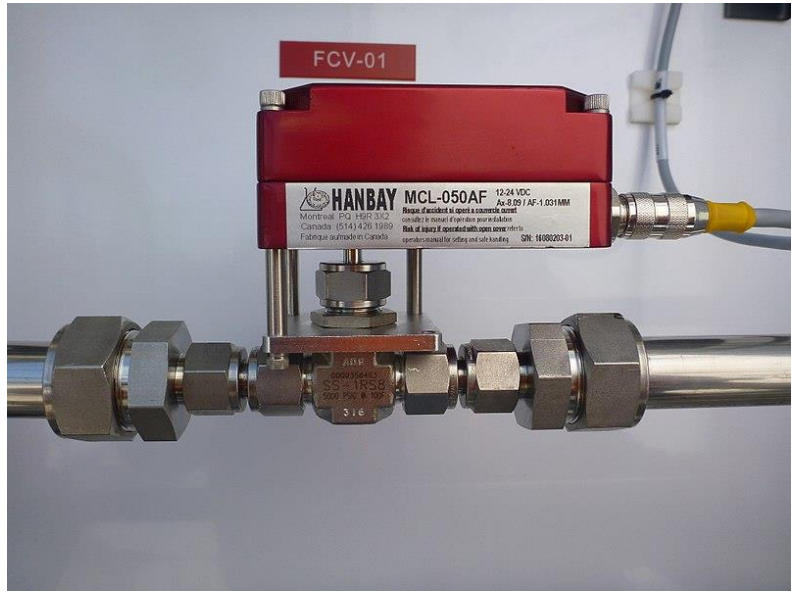
CLASS PROFILE

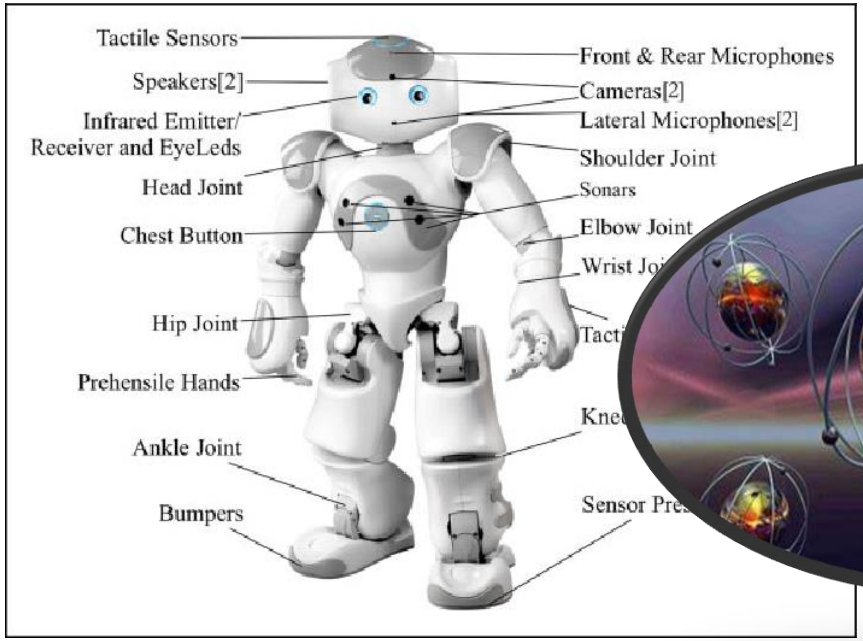
Parameters	Sensor	Actuator
Basics	Sensors convert the physical characteristics from their environment to electrical signals for the system.	Actuators convert the electrical signals from the system to various physical characteristics for their environments.
Source of Input	Sensors receive input from their environments.	Actuators receive input from a system's output conditioning unit.
Output Generation	Sensors generate output for a system's input conditioning unit.	These generate output for their environment.
Type of Output	Electrical signals are generated as output by sensors.	Motion or heat is generated as output by actuators.
Placement	Sensors are placed at a system's input port.	Actuators are placed at a system's output port.
Examples	For instance, thermometers take our body temperatures in the form of physical characteristics, convert the temperatures into electrical signals, and convey them to their systems. Photo-voltaic cells, Tilt sensors, Temperature sensors, Accelerometers, Ultrasonic sensors, etc., are a few types of sensors.	For instance, heaters, comb drives, pneumatic cylinders, hydraulic cylinders, and electric motors

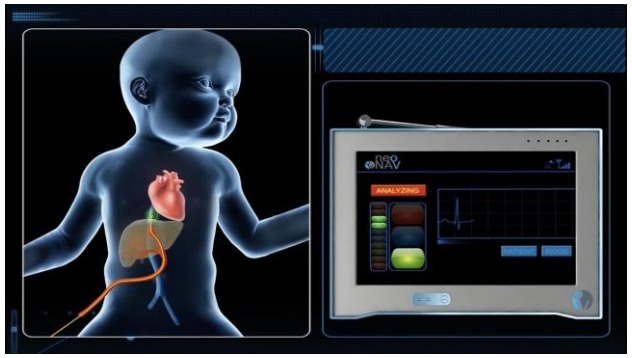
Sensor versus Actuators

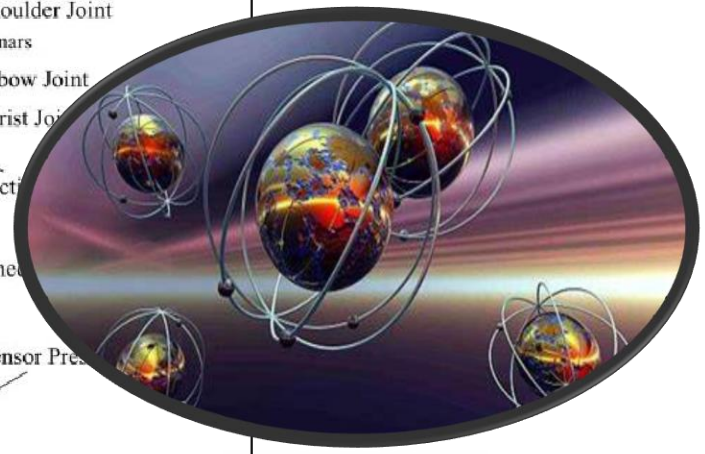
COURSE RATIONALE

- Industrial applications
- Medical applications
- Space applications
- Mechatronic system design









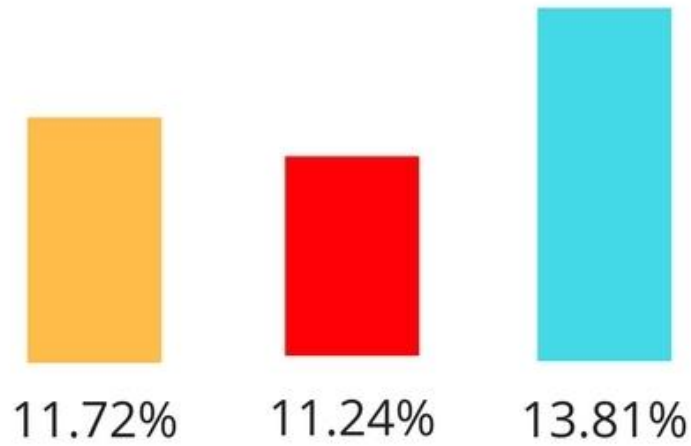
Home / Reports / Sensor and Control / Sensor Market

Sensor Market Research Report Information By Type (Image Sensors, Biosensors, Optical Sensors, Motion Sensors, Pressure Sensors, Temperature Sensors, Humidity Sensors, Radar Sensors, Touch Sensors, Proximity Sensors, and Level Sensors), By Component (Microcontrollers, Transceivers, Amplifiers, and ADC & DAC), By Technology (MEMS, CMOS, and NEMS), By Verticals (Consumer Electronics, Automotive, Industrial IT & Telecom, Healthcare, Aerospace & Defense, Food & Beverages, and Construction), And By Region (North America, Europe, Asia-Pacific, An

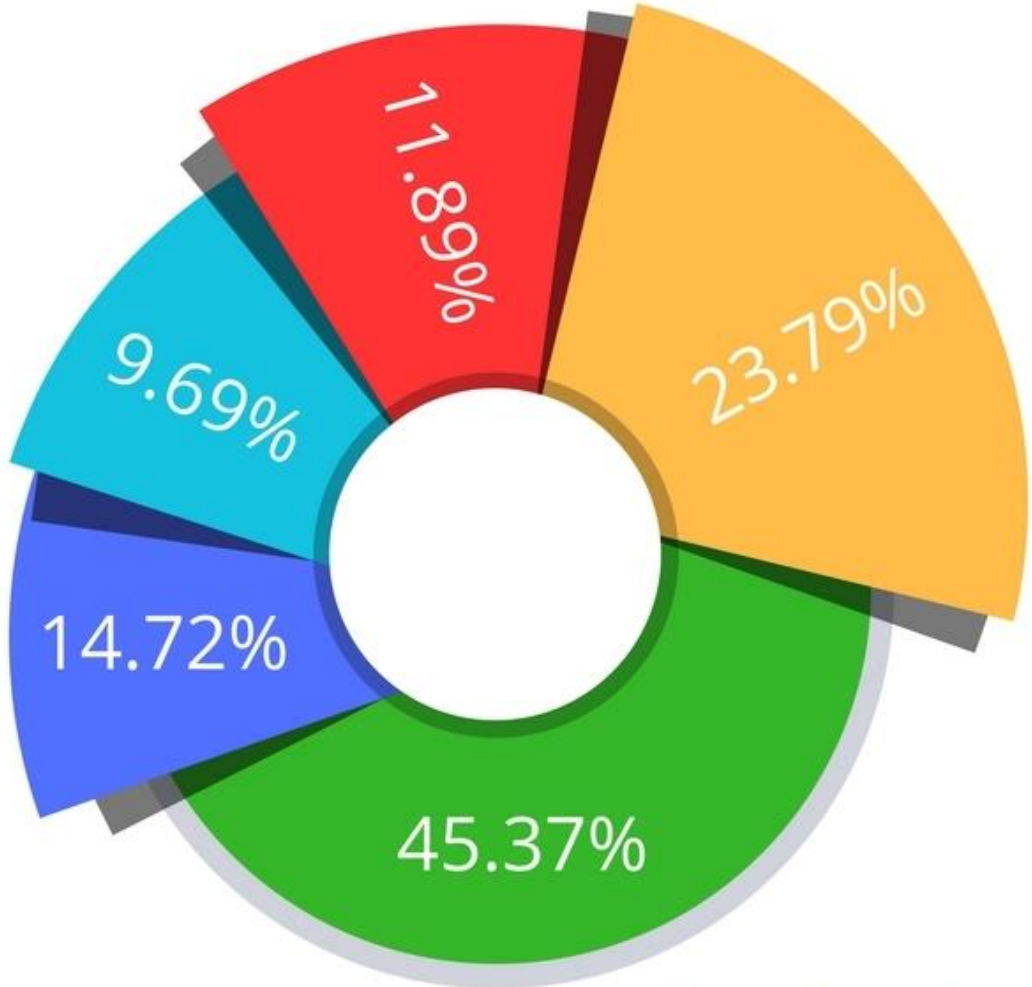
ID: MRFR/SEM/2983-CR | 302 Pages | Author: **Aarti Dhapte** | October 2020

GLOBAL INDUSTRIAL WIRELESS SENSORS MARKET BY PRODUCT

CAGR 2016-2021



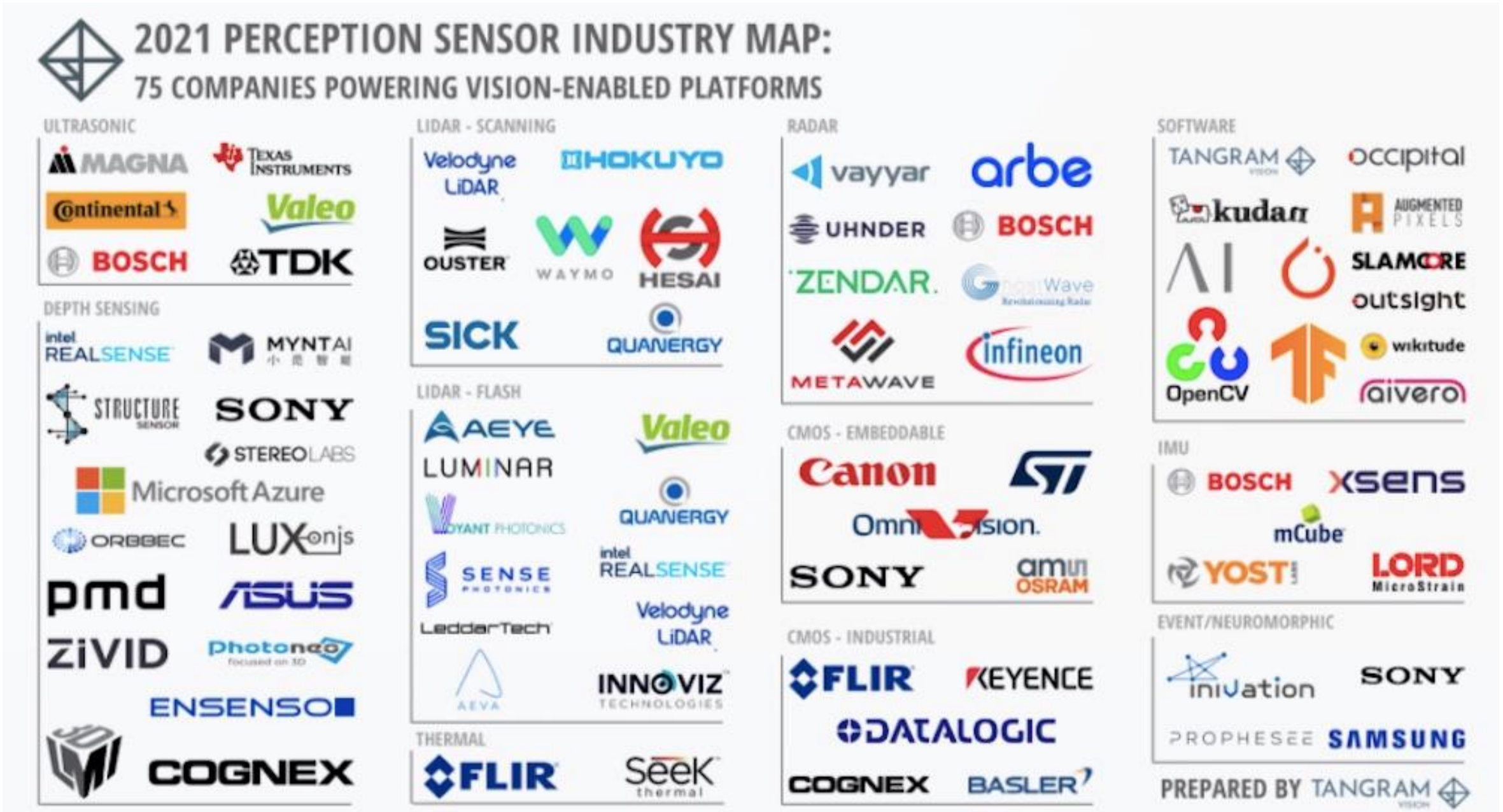
2016 MARKET SHARE



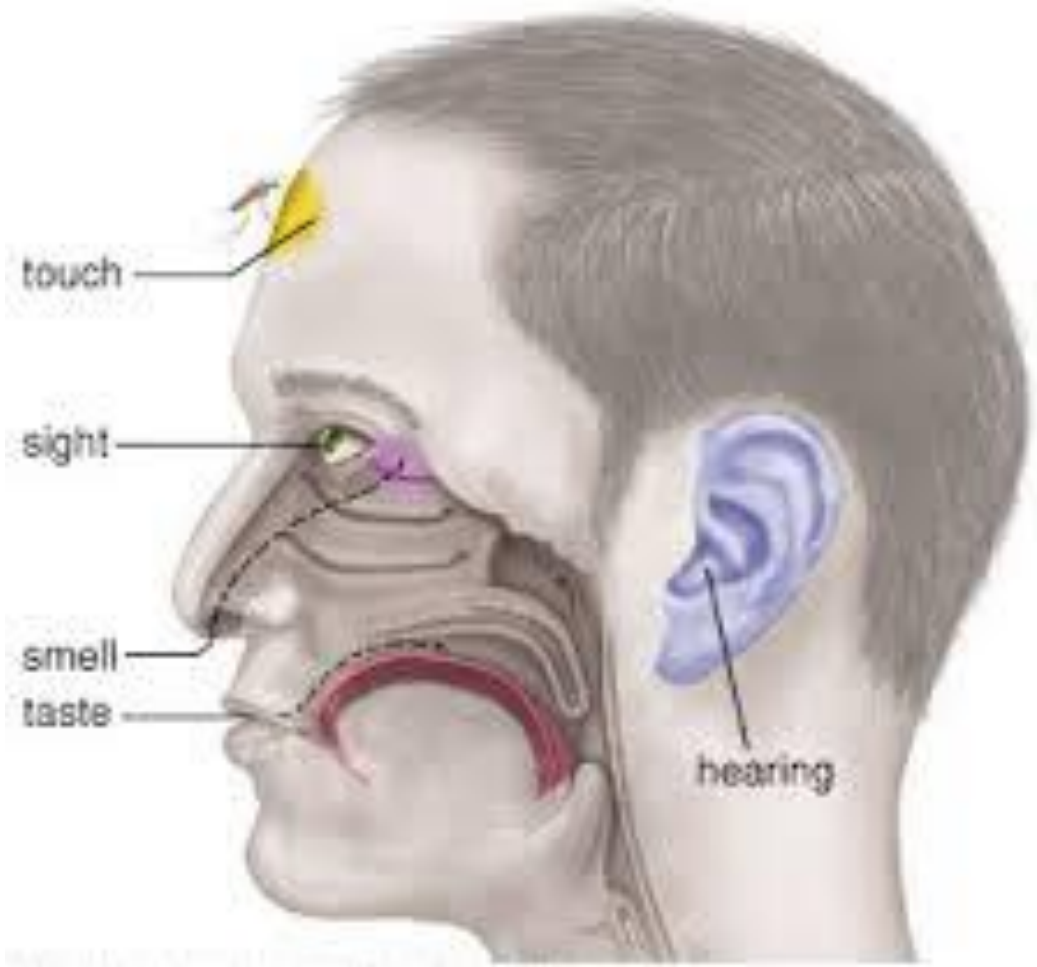
LEGEND

- FLOW SENSORS
- GAS SENSORS
- OTHERS
- TEMPERATURE SENSORS
- PRESSURE SENSORS

technavio


2021 PERCEPTION SENSOR INDUSTRY MAP:
75 COMPANIES POWERING VISION-ENABLED PLATFORMS
ULTRASONIC
MAGNA
Texas Instruments
Continental
Valeo
BOSCH
TDK
DEPTH SENSING
intel REALSENSE
MYNTAI
STRUCTURE SENSOR
SONY
STEREOLABS
Microsoft Azure
ORBBEC
LUXonjs
pmd
ASUS
ZiVID
Photoneo
ENSENSO
COGNEX
LIDAR - SCANNING
Velodyne LiDAR
HOKUYO
OUSTER
WAYMO
HESAI
SICK
QUANERGY
LIDAR - FLASH
AEYE
Valeo
LUMINAR
QUANERGY
SENSE PHOTONICS
intel REALSENSE
LeddarTech
Velodyne LiDAR
AEVA
INNOVIZ TECHNOLOGIES
THERMAL
FLIR
SeeK thermal
RADAR
vayyar
arbe
UHNDER
BOSCH
ZENDAR
Wave
METAWAVE
infineon
CMOS - EMBEDDABLE
Canon
Omni Vision
SONY
ams OSRAM
CMOS - INDUSTRIAL
FLIR
KEYENCE
DATALOGIC
COGNEX
BASLER
SOFTWARE
TANGRAM VISION
occipital
kudan
AUGMENTED PIXELS
SLAMCORE
outsight
wikitude
OpenCV
aivero
IMU
BOSCH
XSENS
mCube
YOST
LORD MicroStrain
EVENT/NEUROMORPHIC
iniVation
SONY
PROPHESEE
SAMSUNG
PREPARED BY TANGRAM VISION

SOURCE OF INSPIRATION (BY NATURE)



HUMAN SENSORS

Detects
Light

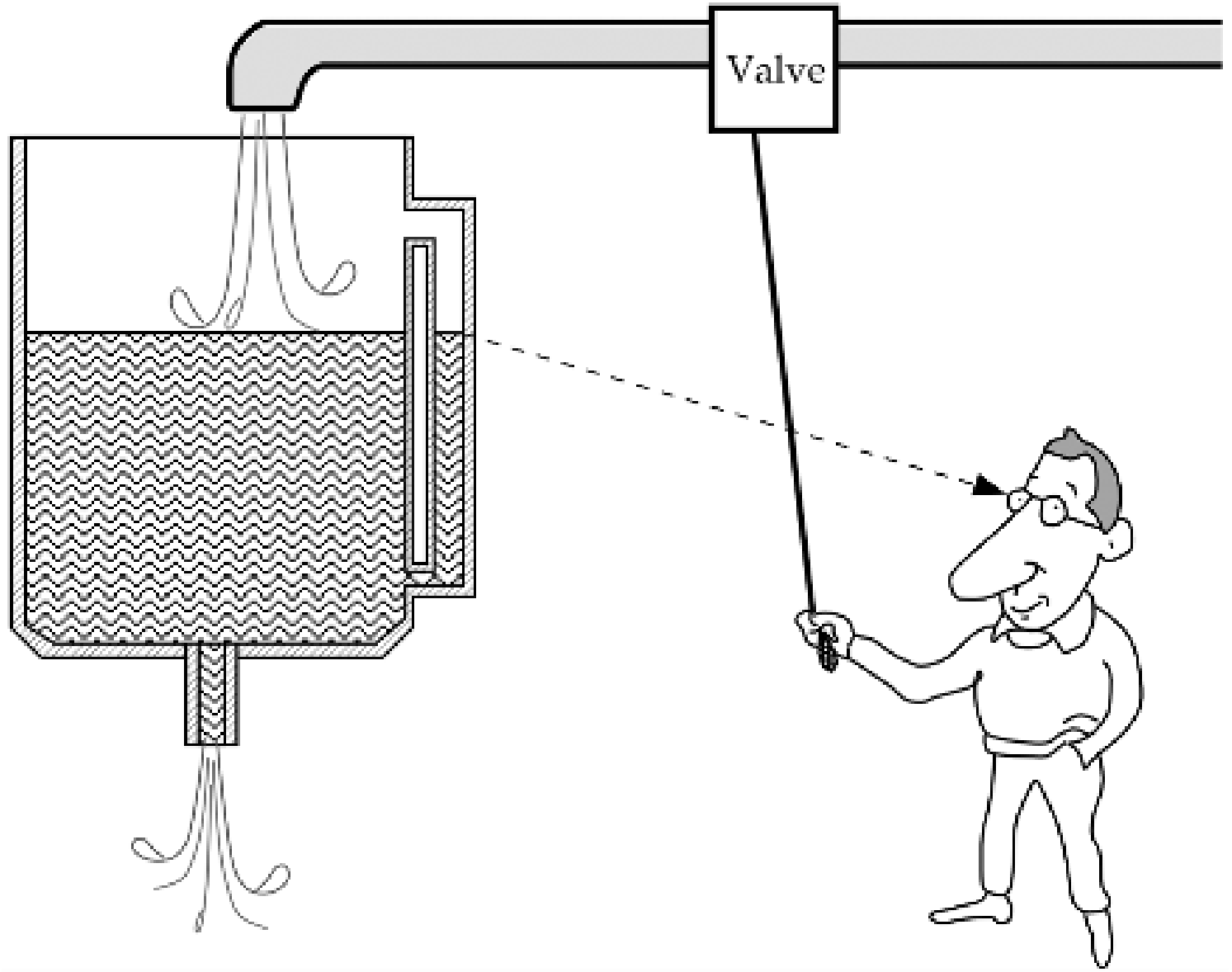
Detects
Sound

Detects
Certain Chemicals

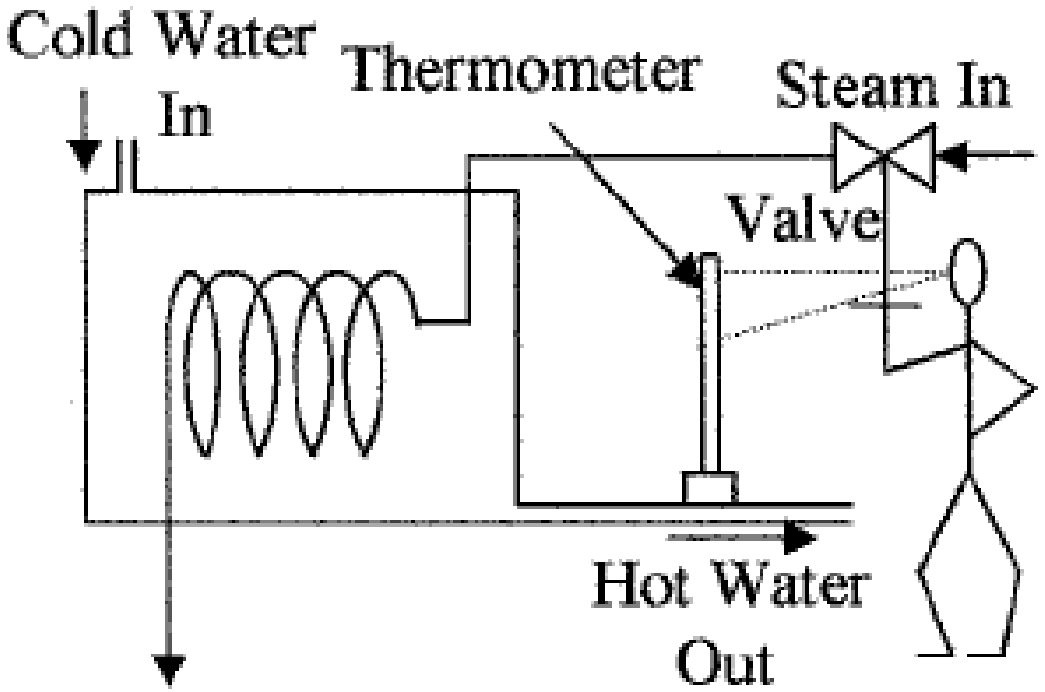
Detects
Pressure & Temperature

SENSOR: DEFINED

A sensor is often defined as a *device that receives and responds to a signal or stimulus*.

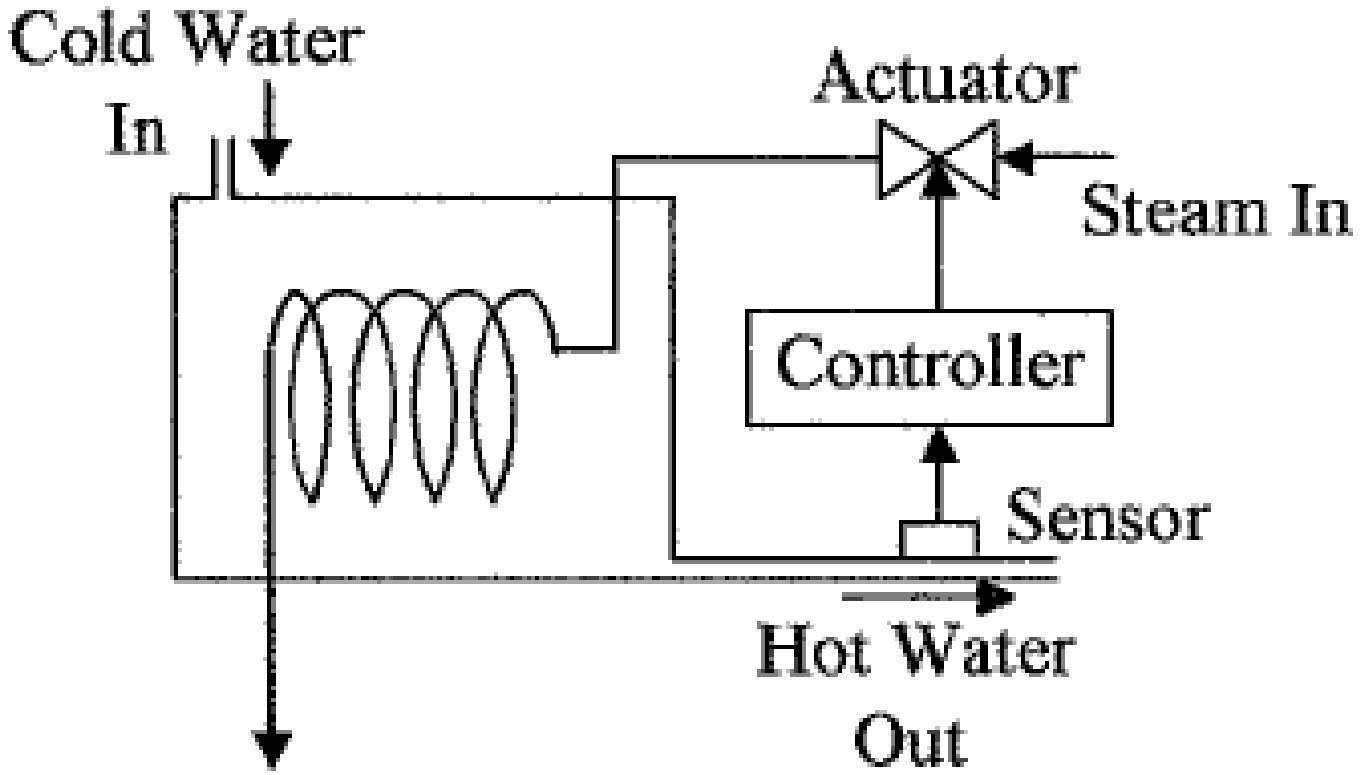

Valve

MANUAL MODE CONTROL



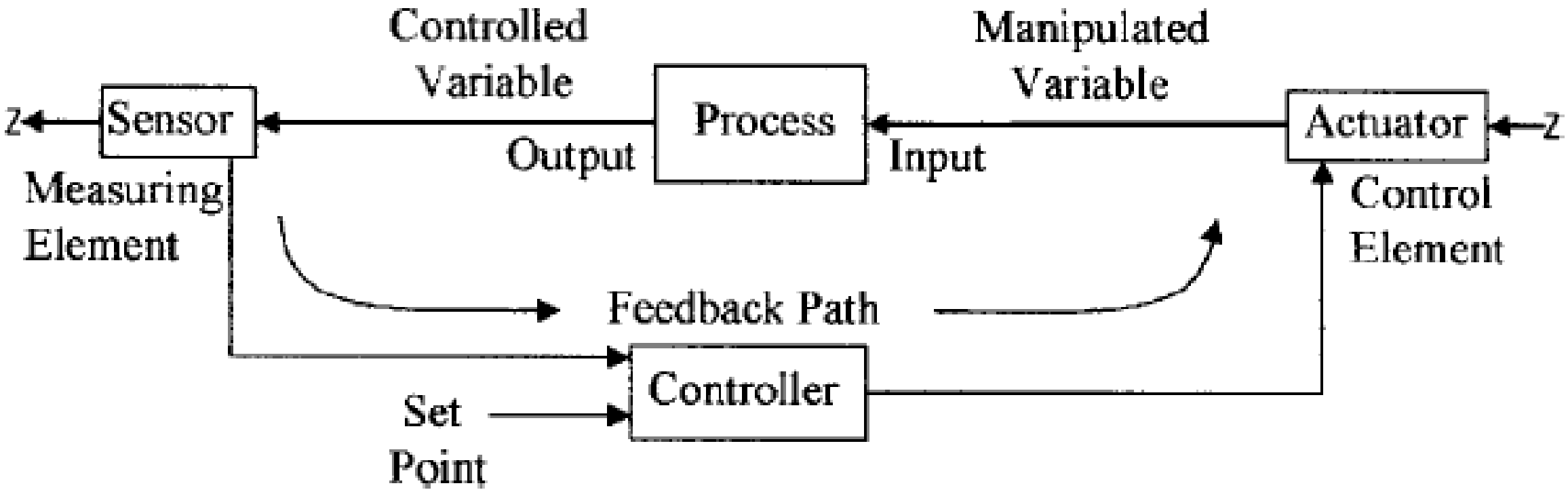
(a)

AUTO MODE CONTROL



(b)

CONTROLLED LOOP

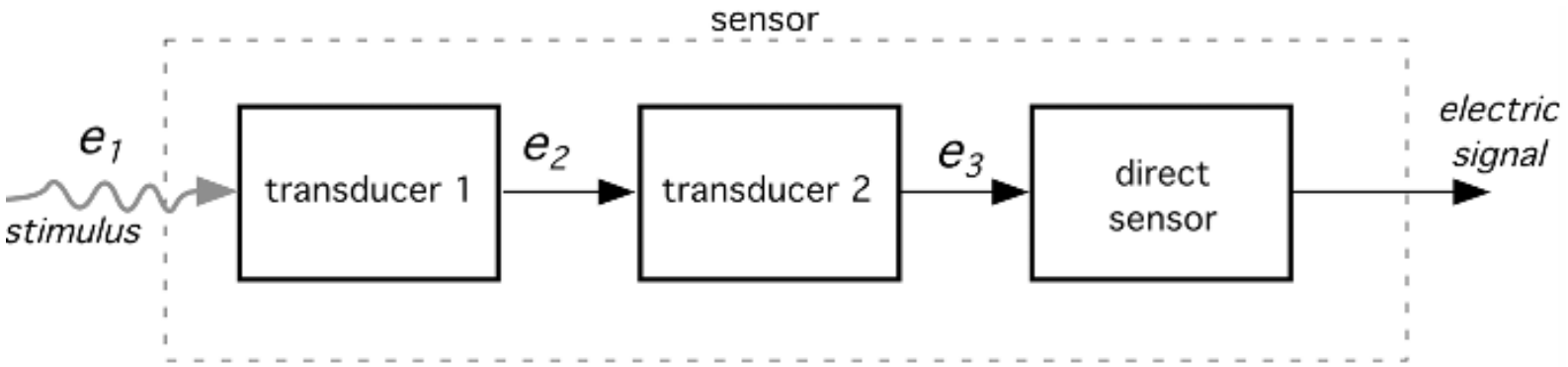


SENSOR: ELECTRICAL SIGNAL

- A sensor is a device that receives a stimulus and responds with an electrical signal.
- **Sensors that are used in artificial systems must speak the same language as the devices with which they are interfaced**

SENSOR: ELECTRICAL SIGNAL

The purpose of a sensor is to respond to some kind of an input physical property (stimulus) and to convert it into an electrical signal which is compatible with electronic circuits.



A MORE REFINED DEFINITION:

A sensor is a device that receives a stimulus and responds with an electrical signal

- A sensor is a translator of a generally nonelectrical value into an electrical value.
- By “electrical,” we mean a signal, which can be channeled, amplified, and modified by electronic devices.
- The sensor’s output signal may be in the form of voltage, current, or charge.
- These may be further described in terms of amplitude, polarity, frequency, phase, or digital code.
- This set of characteristics is called the **output signal format.** Therefore, a sensor has input properties (of any kind) and electrical output properties.

SENSOR: ENERGY CONVERSION

- Any sensor is an energy converter.

  No matter what you try to measure, you always deal with energy transfer from the object of measurement to the sensor

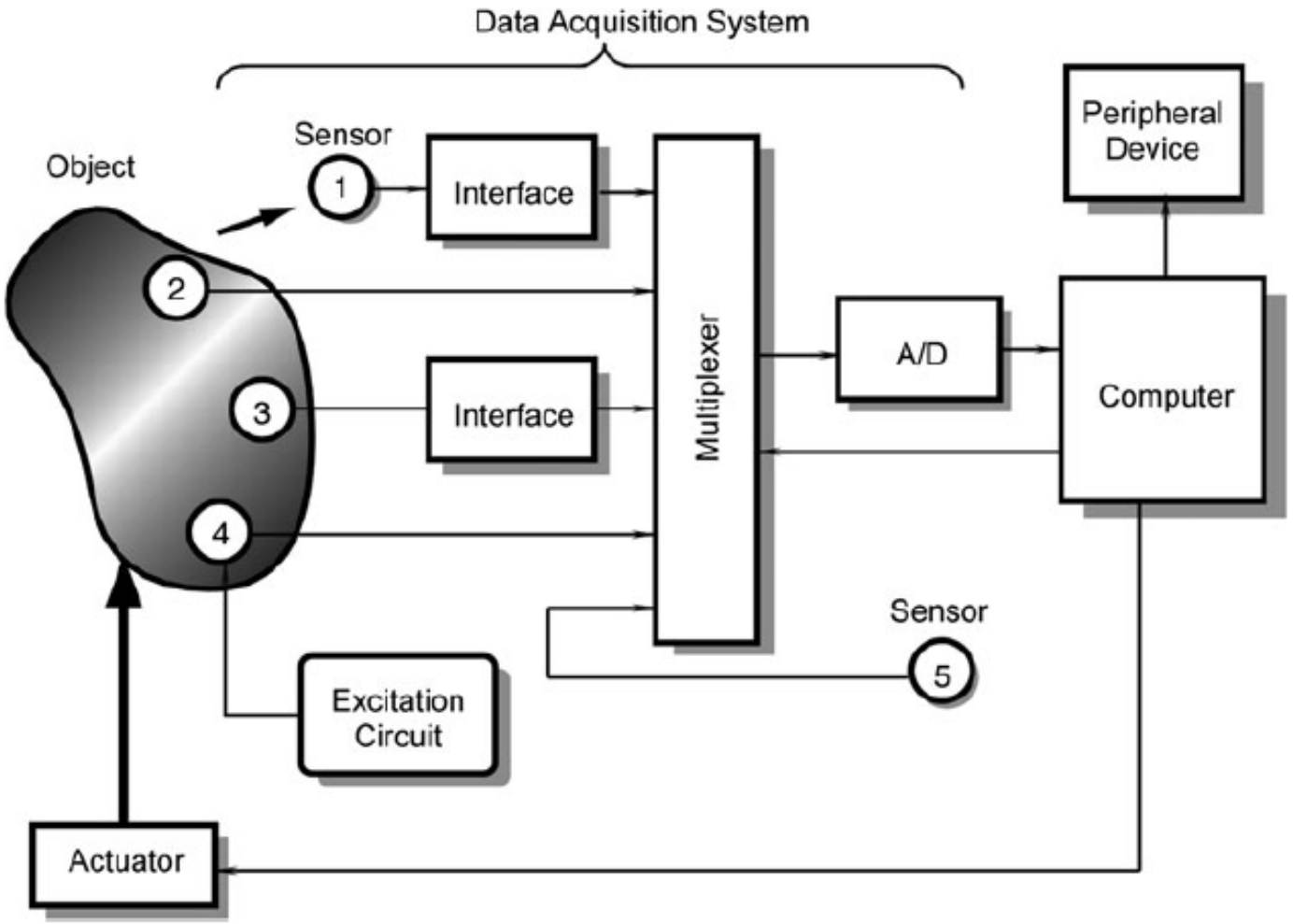
SENSOR VERSUS TRANSDUCER

- The term sensor should be distinguished from transducer. The latter is a converter of any one type of energy into another, whereas the former converts any type of energy into electrical energy.
- An example of a transducer is a loudspeaker, which converts an electrical signal into a variable magnetic field and, subsequently, into acoustic waves
- Transducers may be parts of complex sensors

SENSOR CLASSIFICATIONS

- Passive and Active:
  - A passive sensor does not need any additional energy source and directly generates an electric signal in response to an external stimulus. That is, the input stimulus energy is converted by the sensor into the output signal. The examples are a thermocouple, a photodiode, and a piezoelectric sensor.
  - The active sensors require external power for their operation, which is called an excitation signal. That signal is modified by the sensor to produce the output signal.
  - The active sensors sometimes are called parametric because their own properties change in response to an external effect and these properties can be subsequently converted into electric signals. It can be stated that a sensor's parameter modulates the excitation signal and that modulation carries information of the measured value. For example, a thermistor is a temperature sensitive resistor.

A SENSOR DOES NOT FUNCTION BY ITSELF



SENSOR CLASSIFICATIONS

- Sensors can be classified into **Absolute** and **Relative:**
  - An absolute sensor detects a stimulus in reference to an absolute physical scale that is independent of the measurement conditions, whereas a relative sensor produces a signal that relates to some special case.
  - An example of an absolute sensor is a thermistor, a temperature-sensitive resistor. Its electrical resistance directly relates to the absolute temperature scale of Kelvin.
  - Another very popular temperature sensor thermocouple is a relative sensor. It produces an electric voltage, which is a function of a temperature gradient across the thermocouple wires. Thus, a thermocouple output signal cannot be related to any particular temperature without referencing to a known baseline.
  - Another example of the absolute and relative sensors is a pressure sensor. An absolute pressure sensor produces signal in reference to vacuum – an absolute zero on a pressure scale. A relative pressure sensor produces signal with respect to a selected baseline that is not zero pressure, for example, to the atmospheric pressure.

CLASS ACTIVITY-1

THINK OF A SMALL SYSTEM THAT HAS SOME SENSING AND ACTUATING DEVICES AND ADD VALUE TO THE SURROUNDINGS

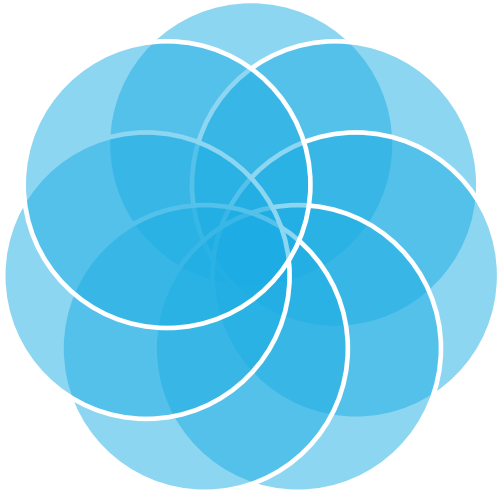
SENSOR SPECIFICATIONS

OVERLOAD CHARACTERISTICS

SENSITIVITY

RESOLUTION

OPERATING LIFE

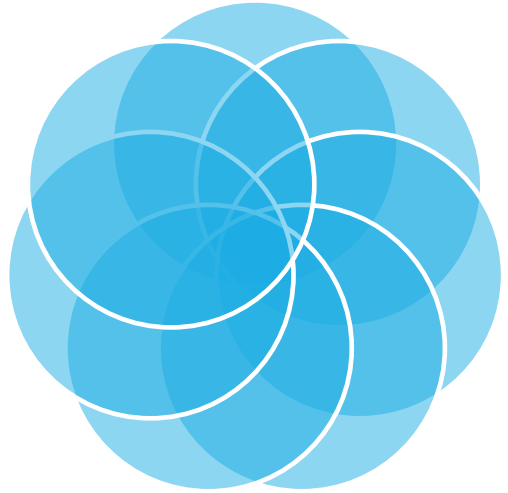


SPEED OF RESPONSE

STIMULUS

DEAD BAND

COST-SIZE-WEIGHT



ACCURACY

STABILITY

LINEARITY

ENVIRONMENTAL CONDITIONS